US011506004B2

# (12) United States Patent
**Gutarov et al.**

(10) **Patent No.: US 11,506,004 B2**
(45) **Date of Patent: Nov. 22, 2022**

(54) **AUTOMATIC DRILLING ACTIVITY DETECTION**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1009 days.

(21) Appl. No.: **16/311,153**

(22) PCT Filed: **Jun. 23, 2016**

(86) PCT No.: **PCT/IB2016/001165**
§ 371 (c)(1),
(2) Date: **Dec. 18, 2018**

(87) PCT Pub. No.: **WO2017/221046**
PCT Pub. Date: **Dec. 28, 2017**

(65) **Prior Publication Data**

US 2019/0264516 A1 Aug. 29, 2019

(51) **Int. Cl.**

| | |
|---|---|
| ***E21B 19/20*** | (2006.01) |
| ***E21B 19/16*** | (2006.01) |

(Continued)

(52) **U.S. Cl.**
CPC ............ ***E21B 19/165*** (2013.01); ***E21B 19/20*** (2013.01); ***E21B 44/00*** (2013.01); ***E21B 44/005*** (2013.01); ***E21B 45/00*** (2013.01); ***E21B 47/04*** (2013.01)

(58) **Field of Classification Search**
CPC ...... E21B 19/165; E21B 19/20; E21B 44/005; E21B 44/00; E21B 45/00; E21B 47/04
See application file for complete search history.

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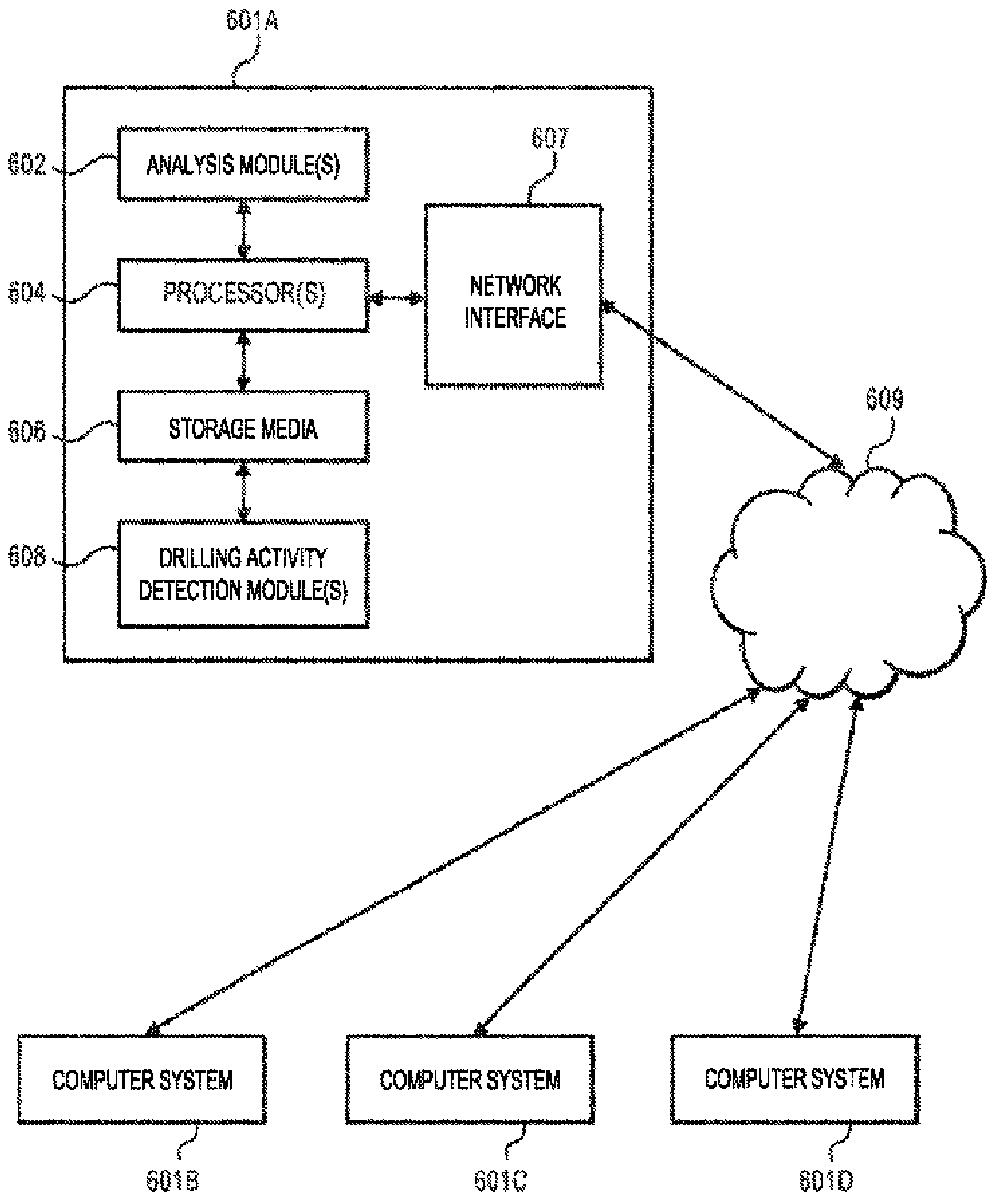
## (57) ABSTRACT

A method of determining a drilling activity includes receiving a set of measurements at different times. The set of measurements includes a depth of a wellbore, a depth of a drill bit, and a position of a travelling block. The method also includes identifying a connection by determining when the position of the travelling block changes but the depth of the drill bit does not change. The method also includes determining when the depth of the wellbore does not increase between two different connections. The method also includes determining a direction that the drill bit moves between the two connections.

**20 Claims, 7 Drawing Sheets**



(51) **Int. Cl.**

| | |
|---|---|
| ***E21B 44/00*** | (2006.01) |
| ***E21B 45/00*** | (2006.01) |
| ***E21B 47/04*** | (2012.01) |

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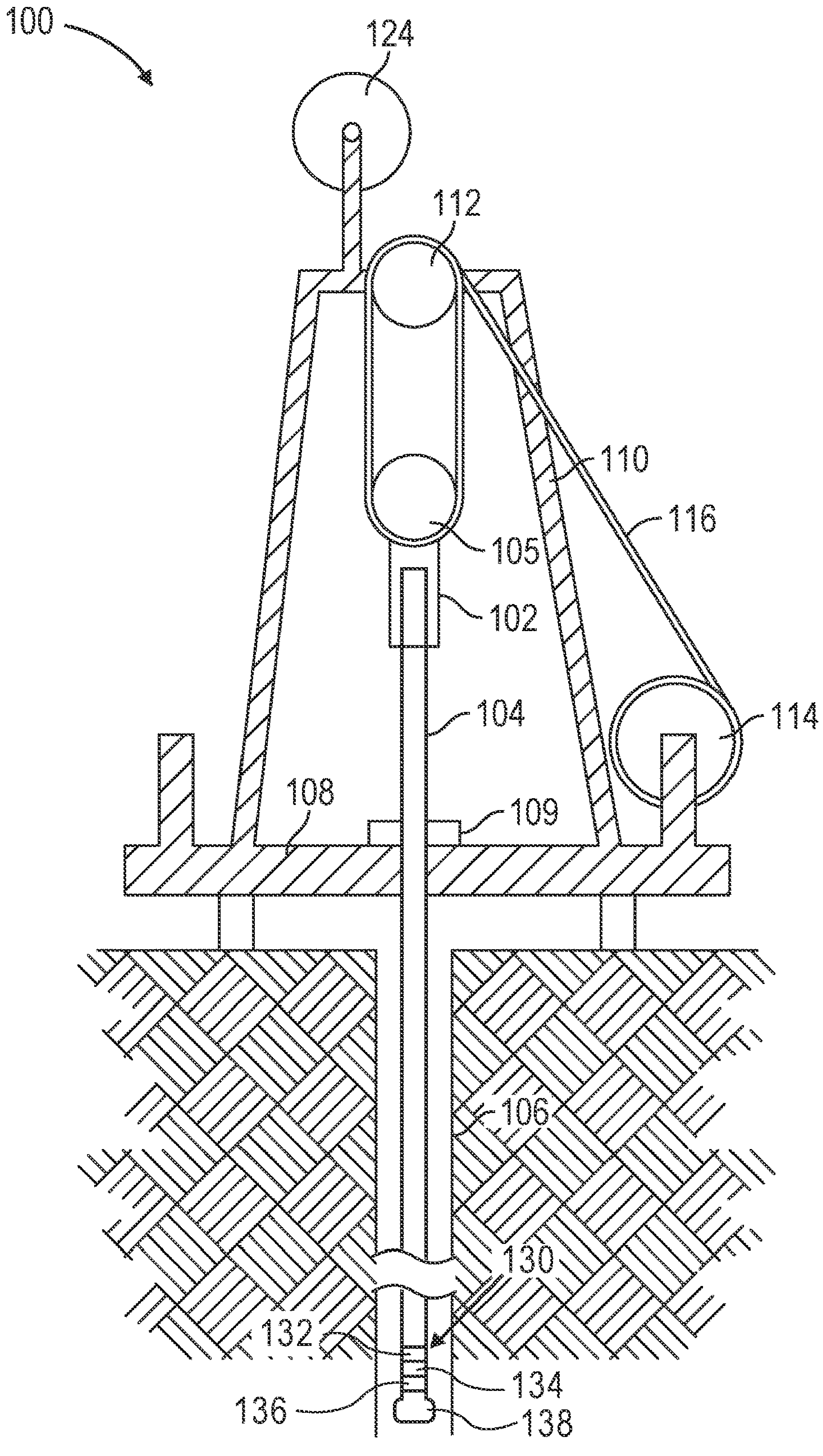

100
124
112
110
116
105
102
104
114
108
109
106
130
132
134
136
138

FIG. 1

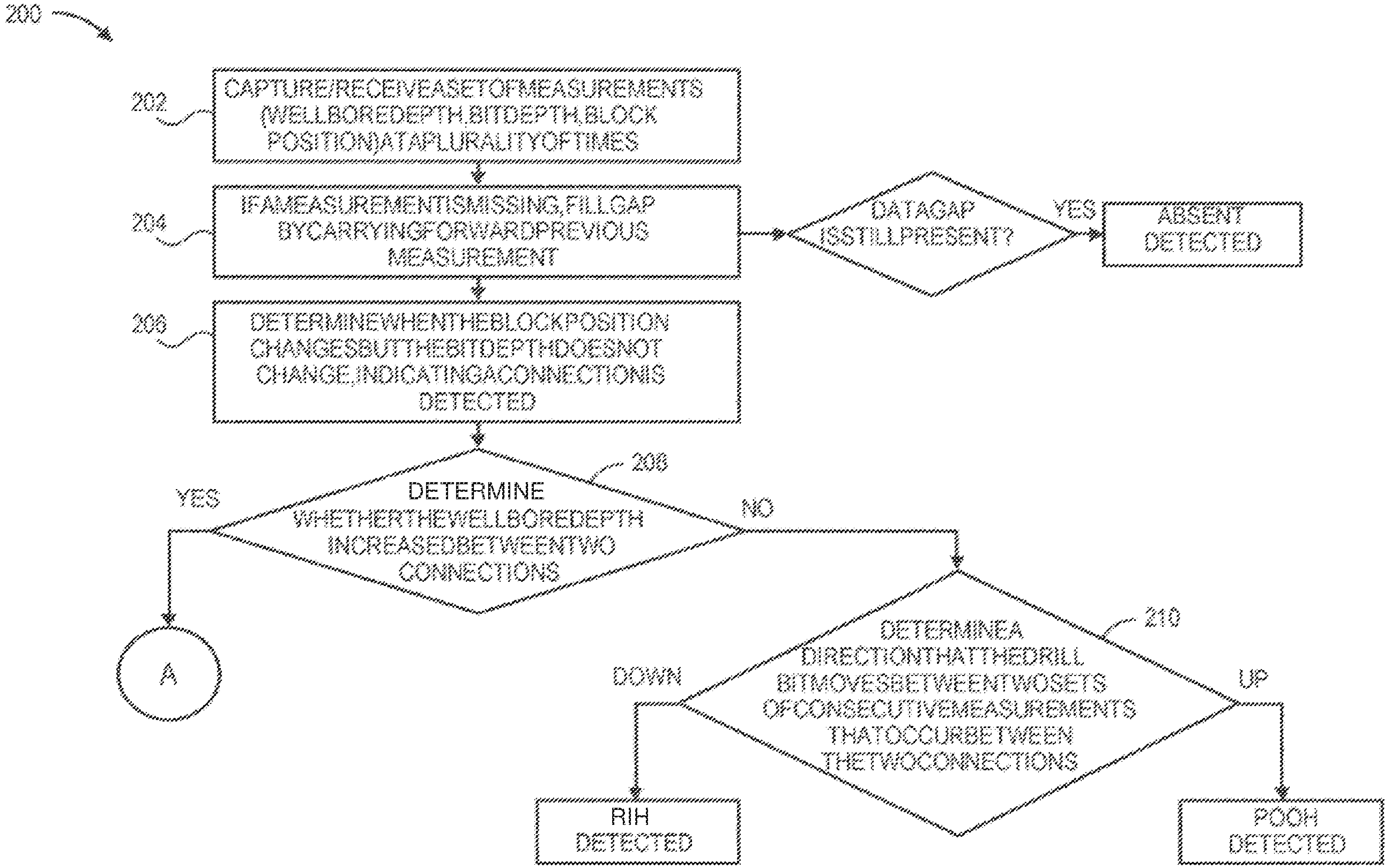

200
202
CAPTURE/RECEIVEASETOFMEASUREMENTS (WELLBOREDEPTH,BITDEPTH,BLOCK POSITION)ATAPLURALITYOFTIMES
204
IFAMEASUREMENTISMISSING,FILLGAP BYCARRYINGFORWARDPREVIOUS MEASUREMENT
DATAGAP ISSTILLPRESENT?
YES
ABSENT DETECTED
206
DETERMINEWHENTHEBLOCKPOSITION CHANGESBUTTHEBITDEPTHDOESNOT CHANGE,INDICATINGACONNECTIONIS DETECTED
208
DETERMINE WHETHERTHEWELLBOREDEPTH INCREASEDBETWEENTWO CONNECTIONS
YES
NO
A
210
DETERMINEA DIRECTIONTHATTHEDRILL BITMOVESBETWEENTWOSETS OFCONSECUTIVEMEASUREMENTS THATOCCURBETWEEN THETWOCONNECTIONS
DOWN
UP
RIH DETECTED
POOH DETECTED

FIG. 2A

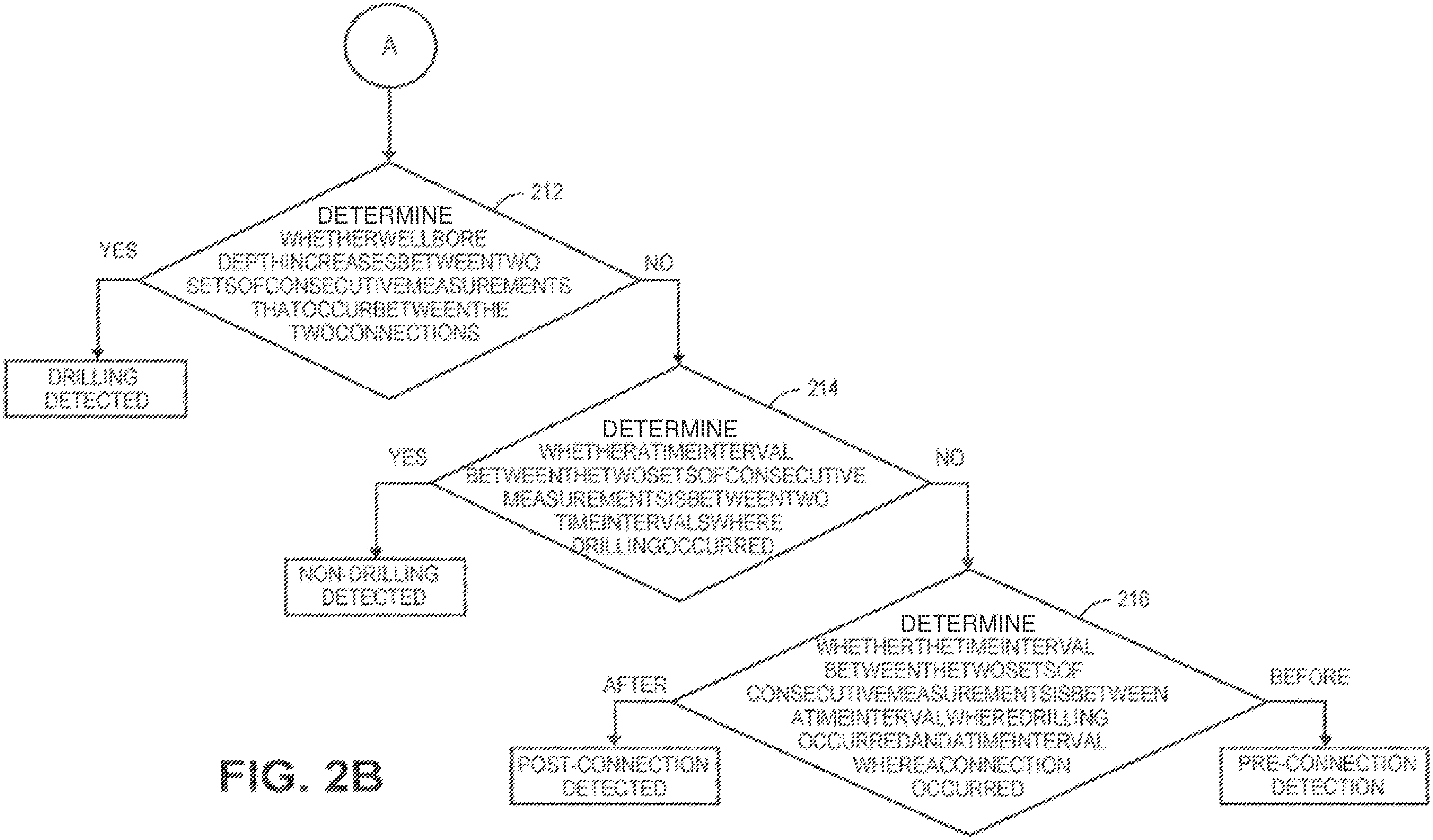
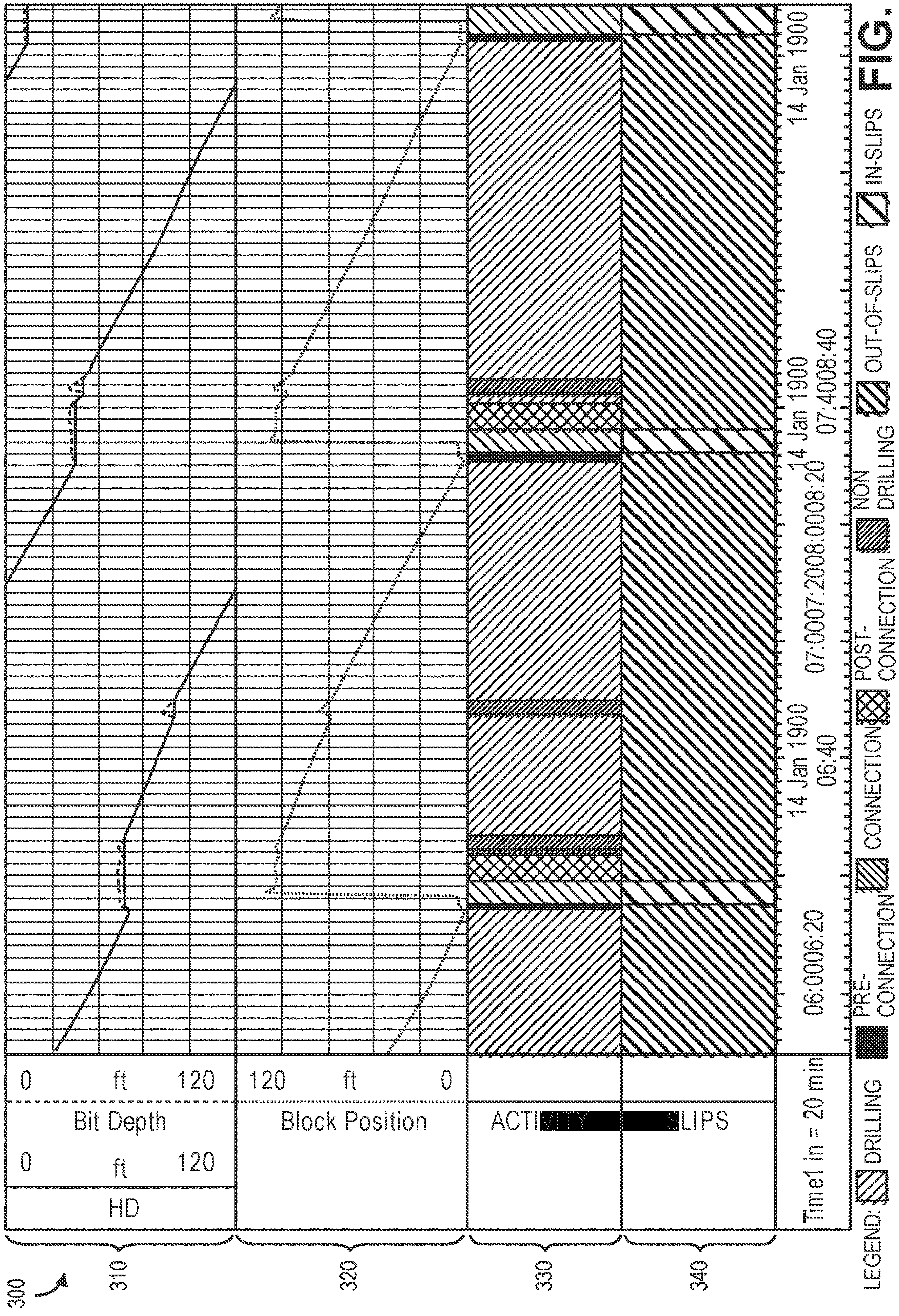

A
DETERMINE
WHETHERWELLBORE
DEPTHINCREASESBETWEENTWO
SETSOFCONSECUTIVEMEASUREMENTS
THATOCCURBETWEENTHE
TWOCONNECTIONS
212
YES
NO
DRILLING
DETECTED
DETERMINE
WHETHERATIMEINTERVAL
BETWEENTHETWOSETSOFCONSECUTIVE
MEASUREMENTSISBETWEENTWO
TIMEINTERVALSWHERE
DRILLINGOCCURRED
214
YES
NO
NON-DRILLING
DETECTED
DETERMINE
WHETHERTHETIMEINTERVAL
BETWEENTHETWOSETSOF
CONSECUTIVEMEASUREMENTSISBETWEEN
ATIMEINTERVALWHEREDRILLING
OCCURREDANDATIMEINTERVAL
WHEREACONNECTION
OCCURRED
216
AFTER
BEFORE
POST-CONNECTION
DETECTED
PRE-CONNECTION
DETECTION

FIG. 2B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310
320
330
340
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0 ft 120
HD
120 ft 0
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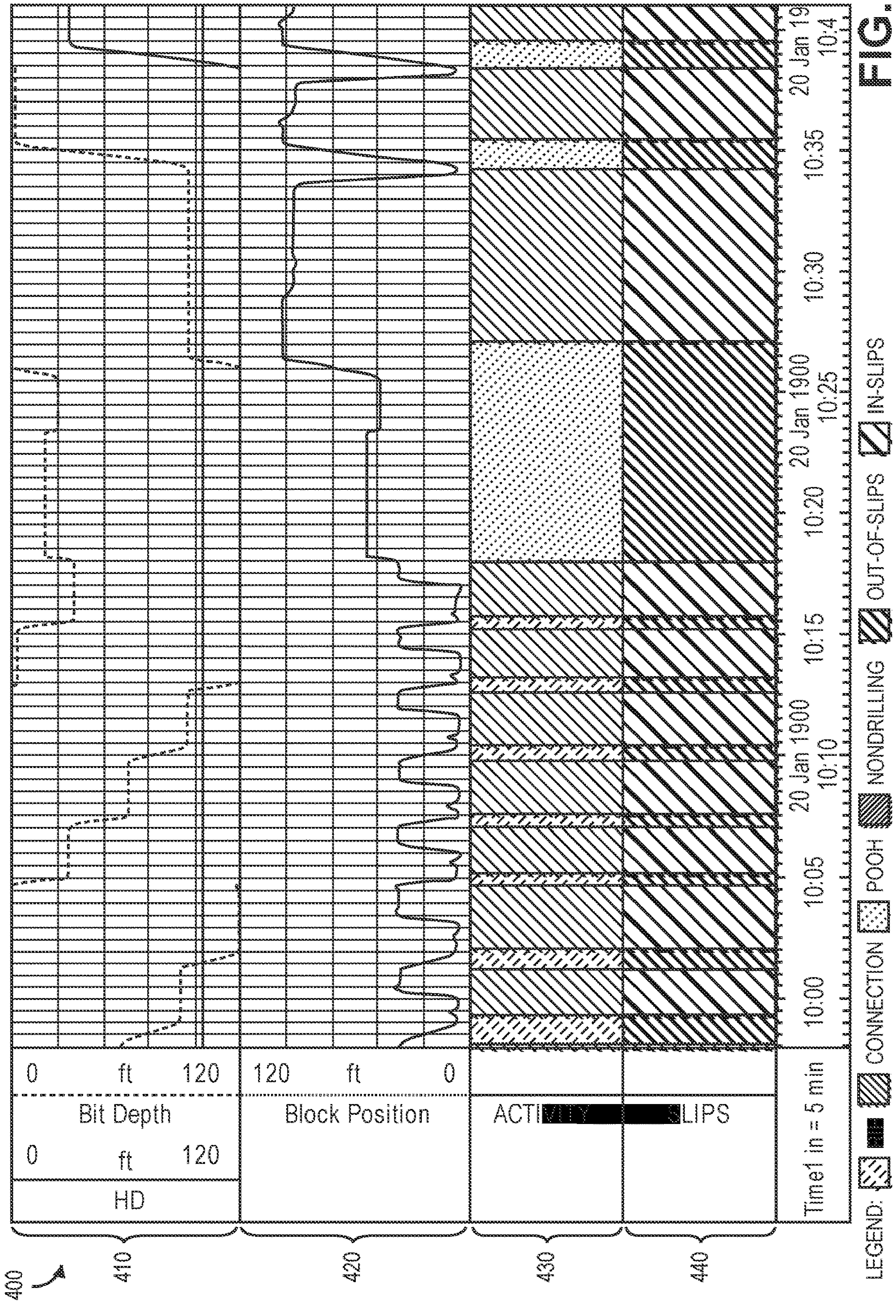
ACTI[redacted]
[redacted]LIPS
Time1 in = 20 min
06:00
06:20
14 Jan 1900
06:40
07:00
07:20
08:00
08:20
14 Jan 1900
07:40
08:40
14 Jan 1900
LEGEND:
▨ DRILLING
■ PRE-CONNECTION
▨ CONNECTION
▩ POST-CONNECTION
▩ NON DRILLING
▨ OUT-OF-SLIPS
▨ IN-SLIPS

FIG. 3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410
420
430
440
0 ft 120
Bit Depth
0 ft 120
HD
120 ft 0
Block Position
ACTI[redacted]LIPS
Time1 in = 5 min
10:00
10:05
20 Jan 1900
10:10
10:15
10:20
20 Jan 1900
10:25
10:30
10:35
20 Jan 19
10:4
LEGEND: ▨ [redacted] ▨ CONNECTION ▨ POOH ▨ NONDRILLING ▨ OUT-OF-SLIPS ▨ IN-SLIPS

FIG. 4

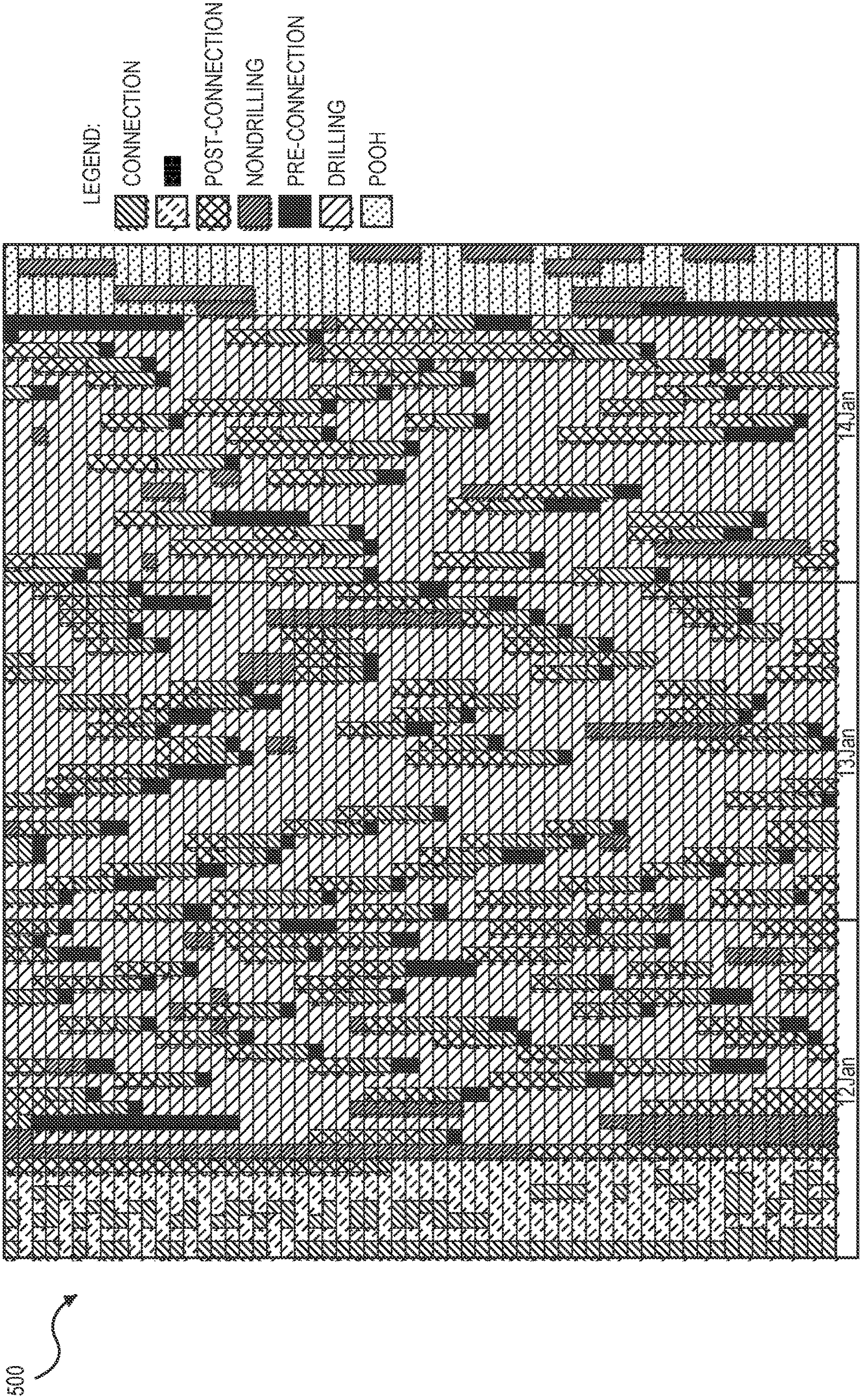
LEGEND:
▨ CONNECTION
▨ ■
▨ POST-CONNECTION
▨ NONDRILLING
■ PRE-CONNECTION
▨ DRILLING
▨ POOH
14Jan
13Jan
12Jan
500

FIG. 5

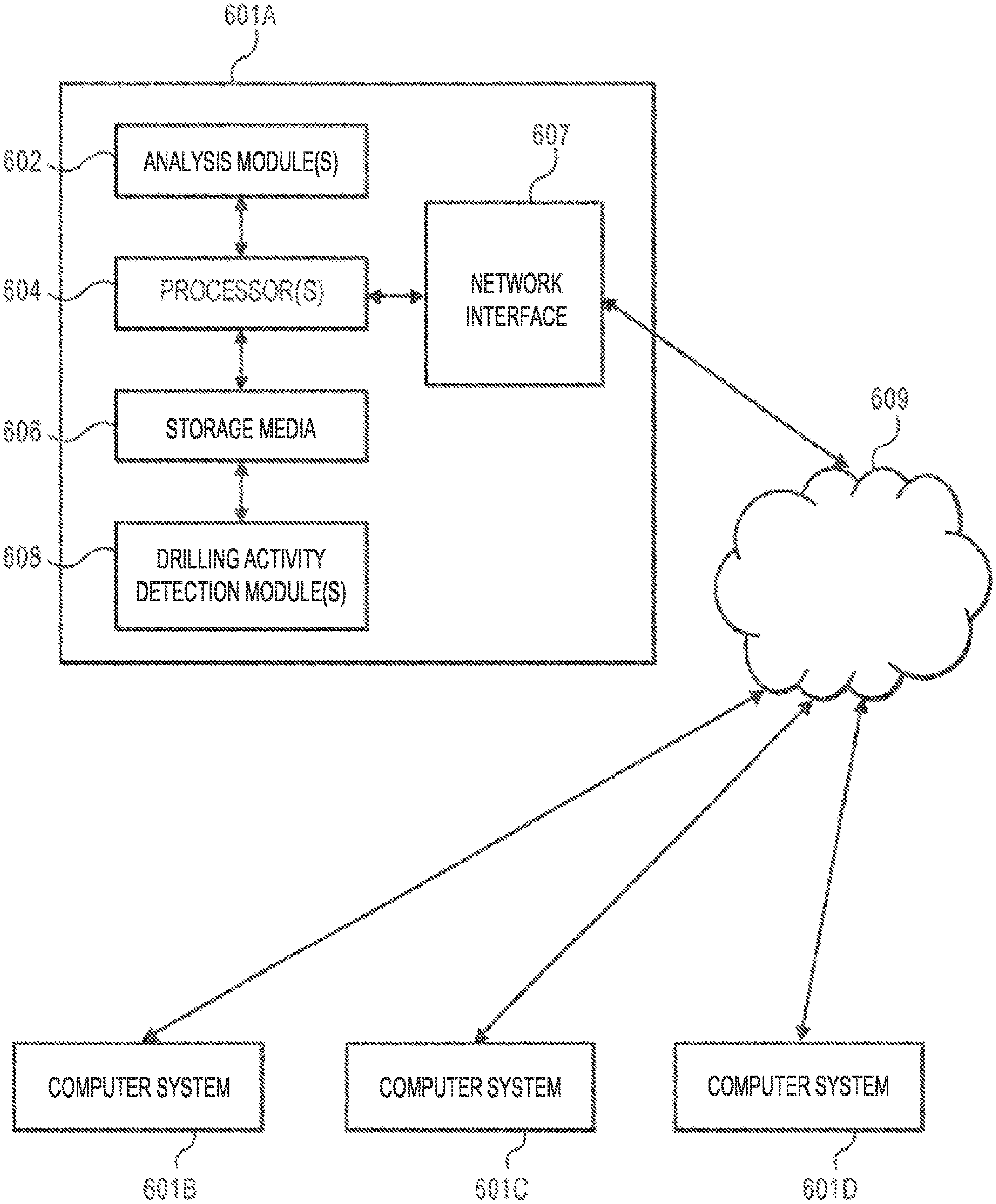
601A
602
ANALYSIS MODULE(S)
604
PROCESSOR(S)
606
STORAGE MEDIA
608
DRILLING ACTIVITY DETECTION MODULE(S)
607
NETWORK INTERFACE
609
COMPUTER SYSTEM
COMPUTER SYSTEM
COMPUTER SYSTEM
601B
601C
601D

FIG. 6

# AUTOMATIC DRILLING ACTIVITY DETECTION

## BACKGROUND

To increase a length of a drill string, the drill string may be disconnected from a drilling device (e.g., a top drive) and gripped by a slips assembly at the surface to support the drill string. With the drill string supported, another segment (referred to as a drill pipe) may be added to the upper end of the drill string to increase the length of the drill string for deeper drilling. After the increased drill string has been reconnected back to the drilling device, the slips assembly may then release the drill string, and a bottom-hole assembly, which is coupled to a lowermost segment of the drill string, may resume drilling. After the bottom-hole assembly advances the length of the wellbore by the length of the additional segment, the drilling process may be stopped, the drill string is again gripped by the slips assembly, disconnected from the drilling device, and another segment added to the drill string. This is repeated over and over to drill deeper and deeper.

Oftentimes, the overall weight carried by the drilling device (called the "hook load") is monitored to determine when the drill string is gripped by the slips assembly. As used herein, "hook load" refers to a total force pulling down on the hook, supporting the drilling device, at the surface. This force includes the weight of the drill string and any downhole tools (e.g., the bottom-hole assembly) coupled to the drill string, reduced by any force that lessens the weight, such as friction along the wellbore wall and buoyant forces caused by the immersion in drilling fluid. The hook load may or may not include the weight of the drilling device. When the hook load decreases by a relatively large amount, the user may determine that the drill string is in the slips assembly. However, occasionally, the hook load measurements include noise (e.g., spikes) that may adversely affect calculations of non-productive time ("NPT"), invisible loss time ("ILT"), and the like.

## SUMMARY

A method of determining a drilling activity is disclosed. The method includes receiving a set of measurements at different times. The set of measurements includes a depth of a wellbore, a depth of a drill bit, and a position of a travelling block. The method also includes identifying a connection by determining when the position of the travelling block changes but the depth of the drill bit does not change. The method also includes determining when the depth of the wellbore does not increase between two different connections. The method also includes determining a direction that the drill bit moves between the two connections.

A computer readable medium is also disclosed. The medium stores instructions thereon that, when executed by a processor, cause the processor to perform operations. The operations include receiving a set of measurements different times. The set of measurements includes a depth of a wellbore, a depth of a drill bit, and a position of a travelling block. The operations also include identifying a connection by determining when the position of the travelling block changes but the depth of the drill bit does not change. The operations also include determining when the depth of the wellbore increases between two different connections. The operations also include determining when the depth of the wellbore does not increase between two consecutive sets of measurements that occur between the two connections.

A computing system is also disclosed. The computing system includes a processor and a memory system. The memory system includes a non-transitory computer readable medium storing instructions thereon that, when executed by the processor, causes cause the computing system to perform operations. The operations include receiving a set of measurements at different times. The set of measurements includes a depth of a wellbore, a depth of a drill bit, and a position of a travelling block. The operations also include identifying a connection by determining when the position of the travelling block changes but the depth of the drill bit does not change. The operations further include determining whether the depth of the wellbore increases between two different connections. If the depth of the wellbore increases between two different connections, the operations include determining whether the depth of the wellbore increases between two consecutive sets of measurements that occur between the two connections. However, if the depth of the wellbore does not increase between the two consecutive sets of measurements, the operations include determining whether a time interval between the two consecutive sets of measurements is between two time intervals where drilling occurs.

The foregoing summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the present teachings and together with the description, serve to explain the principles of the present teachings. In the figures:

FIG. **1** illustrates a schematic view of a drilling rig, according to an embodiment.

FIG. **2** illustrates a flowchart of a method for determining a drilling activity, according to an embodiment.

FIG. **3** illustrates a graph showing time intervals including drilling, pre-connection, connection, post-connection, and non-drilling activity, according to an embodiment.

FIG. **4** illustrates a graph showing time intervals where the drill string and downhole tool are run into the wellbore ("RIH") and pulled out of the wellbore ("POOH"), according to an embodiment.

FIG. **5** illustrates a graph showing time intervals including when the drill string and downhole tool are run into the wellbore, when pre-connections occur, when connections occur, when post-connections occur, when the downhole tool (e.g., the drill bit) is drilling, when the downhole tool (e.g., the drill bit) is not drilling, and when the drill string and downhole tool are pulled out of the wellbore, according to an embodiment.

FIG. **6** illustrates a schematic view of a computing system that may perform at least a portion of the method(s) disclosed herein, according to an embodiment.

## DETAILED DESCRIPTION

The following detailed description refers to the accompanying drawings. Wherever convenient, the same reference numbers are used in the drawings and the following description to refer to the same or similar parts. While several embodiments and features of the present disclosure are described herein, modifications, adaptations, and other implementations are possible, without departing from the spirit and scope of the present disclosure.

FIG. **1** illustrates a schematic view of a drilling rig **100**, according to an embodiment. The drilling rig **100** includes a drilling apparatus **102** and a drill string **104** coupled thereto. The drilling apparatus **102** may include any type of drilling device, such as a top drive, a rotary table, or any other device configured to support, lower, and rotate the drill string **104**, which may be deployed into a wellbore **106**. In the illustrated embodiment, the drilling apparatus **102** may also include a travelling block **105**, which may include one or more rotating sheaves.

The drilling rig **100** may also include a rig floor **108**, from which a support structure (e.g., including a mast) **110** may extend. A slips assembly **109** may be disposed at the rig floor **108**, and may be configured to engage the drill string **104** so as to enable additional segments to be added to, or removed from, the drill string **104** via the drilling apparatus **102**. More particularly, the slips assembly **109** may be used to grip the drill string **104** and suspend it in the drilling apparatus **102**. The slips assembly **109** may include three or more metallic wedges that are hinged together, forming a near circle around the drill string **104**. The inner surface of the slips assembly **109** may include replaceable, metallic teeth that embed slightly into the side of the drill string **104**. The outer surface of the slips assembly **109** may be tapered to match the taper of the drilling apparatus **102**. Once the slips assembly **109** is in place around the drill string **104**, the driller may slowly lower the drill string **104**. As the drill string **104** descends, the teeth on the inside of the slips assembly **109** grip the drill string **104**, and the slips assembly **109** is pulled downward. This downward force causes the wedges to provide a radially-inward compressive force on the drill string **104**. With the drill string **104** suspended in the slips assembly **109**, the rig crew may then add (e.g., screw) a new stand of drill pipe to the upper end of the drill string **104** to increase the length of the drill string **104**. During tripping out operations, with the drill string **104** suspended in the slips assembly **109**, the rig crew may remove the uppermost segment of the drill string **104** to decrease the length of the drill string **104**. The driller may then raise the drill string **104** to unlock the gripping action of the slips assembly **109**.

A crown block **112** may be coupled to the support structure **110**. Further, a drawworks **114** may be coupled to the rig floor **108**. A drill line **116** may extend between the drawworks **114** and the crown block **112**, and may be received through the sheaves of the travelling block **105**. Accordingly, the position of the drilling apparatus **102** may be changed (e.g., raised or lowered) by spooling or unspooling the drilling line **116** from the drawworks **114** (e.g., by rotation of the drawworks **114**).

A downhole tool **130** may be coupled to the drill string **104**. In one embodiment, the downhole tool **130** may be or include a bottom-hole assembly. The downhole tool **130** may include a measurement-while drilling ("MWD") tool **132**, a logging-while-drilling ("LWD") tool **134**, a rotary-steerable tool **136**, and a drill bit **138**.

FIG. **2** illustrates a flowchart of a method **200** for determining a drilling activity, according to an embodiment. The drilling activity may include one or more of the following:

Drilling: The downhole tool **130** (e.g., the drill bit **138**) is drilling to increase the depth of the wellbore **106**.

Non-drilling: Non-drilling activity is occurring. A non-drilling related activity is determined to be occurring when none of the other drilling activities (i.e., drilling, run-in-hole, pulled-out-of-hole, pre-connection, connection, post connection) is/are occurring, but the end of the current drill stand has not yet been reached. During non-drilling, the flow rate of fluid being pumped into the drill string **104** may increase and/or decrease, the rate of rotation of the drill string **104** may increase and/or decrease, the downhole tool **130** (e.g., the drill bit **138**) may move upwards and/or downwards, or any combination thereof. In one example, a non-drilling activity may be or include a time when the drill bit **138** is idle (e.g., not drilling) and the slips assembly **109** is not engaged with the drill string **104**.

Run-in-hole ("RIH"): The drill string **104** and the downhole tool **130** are being run into the wellbore **106**.

Pulled-out-of-hole ("POOH"): The drill string **104** and the downhole tool **130** are being pulled out of the wellbore **106**.

Pre-connection: The downhole tool **130** (e.g., the drill bit **138**) has completed drilling operations for the current section of drill pipe, but the slips assembly **109** has not begun to move (e.g., radially-inward) into engagement with the drill string **104**. During pre-connection, the flow rate of fluid being pumped into the drill string **104** may increase and/or decrease, the rate of rotation of the drill string **104** may increase and/or decrease, the downhole tool **130** (e.g., the drill bit **138**) may move upwards and/or downwards, or any combination thereof.

Connection: The slips assembly **109** is engaged with, and supports, the drill string **104** (i.e., the drill string **104** is "in-slips"). When a connection is occurring, a segment may be added to the drill string **104** to increase the length of the drill string **104**, or a segment may be removed from the drill string **104** to reduce the length of the drill string **104**.

Post-connection: The drill string **104** is released by the slips assembly **109**, and the downhole tool **130** (e.g., the drill bit **138**) are lowered to be on-bottom. During post-connection, the flow rate of fluid being pumped into the drill string **104** may increase/and/or decrease, the rate of rotation of the drill string **104** may increase and/or decrease, the downhole tool **130** (e.g., the drill bit **138**) may move upwards and/or downwards, or any combination thereof.

Absent: No data is received (e.g., at least one of the inputs is missing).

In at least one embodiment, the method **200** may also be used to determine a slips status. The slips status may include one or more of the following:

In-slips: The slips assembly **109** is engaged with, and supports, the drill string **104** (i.e., the drill string **104** is "in-slips").

Out-of-slips: The slips assembly **109** is not engaged with, and does not support, the drill string **104**.

Absent: No data is received (e.g., at least one of the inputs is missing).

The method **200** may begin by capturing/receiving a set of measurements at a plurality of different times, as at **202**. The set of measurements may include (1) a depth of the wellbore **106**, (2) a depth of the drill bit **138**, (3) a position of the travelling block **105**, or a combination thereof. The set of measurements may not include the weight on the hook (i.e., "hook load"), or the weight on the drill bit **138** (i.e., "WOB"). Each set of measurements may be captured/received a predetermined amount of time after the previous set of measurements is captured/received. The predetermined amount of time may be, for example, about three seconds; however, as will be appreciated, the predetermined amount of time may be shorter or longer.

The depth of the wellbore **106** may be measured when the drill bit **138** is "on-bottom." In one example, the depth of the wellbore **106** may be measured by adding (1) the length of the drill string **104** that is below the surface, (2) the length of the downhole tool **130**, and (3) the length(s) of any other components (e.g., joints, subs, etc.) that are below the surface. In another example, the depth of the wellbore **106** may be measured by a sensor in the downhole tool **130**.

The depth of the drill bit **138** may be measured by when the drill bit **138** is "on-bottom" or "off-bottom." When the drill bit **138** is on-bottom, the depth of the drill bit **138** may be the same as the depth of the wellbore **106**. When the drill bit **138** is off-bottom, the depth of the drill bit **138** may be less than the depth of the wellbore **106**. In one example, the depth of the drill bit **138** may be measured by adding (1) the length of the drill string **104** that is below the surface, (2) the length of the downhole tool **130**, and (3) the length(s) of any other components (e.g., joints, subs, etc.) that are below the surface. In another example, the depth of the drill bit **138** may be measured by a sensor in the downhole tool **130**. The position of the travelling block **105** may be measured by an encoder in the drawworks **114**, or using any other suitable device or technique.

The method **200** may also include filling a gap in one of the measurements (e.g., the depth of the wellbore **106**, the depth of the drill bit **138**, and/or the position of the travelling block **105**) by carrying forward a measurement taken at the previous time, as at **204**. For example, if the set of measurements does not include the depth of the wellbore **106** at time $T_n$, the depth of the wellbore **106** at the previous time (e.g., time $T_{n-1}$) may be carried forward (i.e., copied and pasted) to the depth of the wellbore **106** at time $T_n$.

If, after **204**, the gap in the measurements is still present at time $T_n$, the drilling activity "absent" may be recorded in place of the measurement. For example, if the depth of the wellbore **106** was also not measured/recorded at time $T_0$, the value of "absent" may be recorded for the depth of the wellbore **106** at time $T_n$.

The method **200** may also include determining whether the position of the travelling block **105** changes but the depth of the drill bit **138** does not change between two consecutive sets of measurements, as at **206**. When the position of the travelling block **105** changes but the depth of the drill bit **138** does not change, a "connection" may be recorded during the time interval between the two consecutive sets of measurements, indicating that the drill string **104** is in-slips.

The method **200** may also include determining whether the depth of the wellbore **106** increases between two different connections, as at **208**. As used herein, two connections are different when another drilling activity (e.g., drilling, RIH, POOH) occurs between the two connections. As a result, the time interval between the two connections may be greater than the time interval between a consecutive set of measurements. For example, the time interval between the two connections may be from about 4 minutes to about 10 minutes, from about 10 minutes to about 20 minutes, from about 20 minutes, to about 30 minutes, or more.

If the depth of the wellbore **106** does not increase between the two connections, a non-drilling section may be detected. As used herein, a "non-drilling section" refers to a period of time between two connections in which no increase in the depth of the wellbore **106** has occurred. When this occurs, the method **200** may include determining a direction that the drill string **104** and/or the downhole tool **130** (e.g., the drill bit **138**) move(s) between two consecutive sets of measurements that occur between the two connections, as at **210**. For example, if the drill string **104** and/or the downhole tool **130** move downward, it may be determined that the drill string **104** and the downhole tool **130** are being run-in-hole ("RIH") between the two consecutive sets of measurements that occur between the two connections, and if the drill string **104** and/or the downhole tool **130** move upward, it may be determined that the drill string **104** and the downhole tool **130** are being pulled out-of-hole ("POOH") between the two consecutive sets of measurements that occur between the two connections.

If the depth of the wellbore **106** does increase between the two connections, a drilling section may be detected. As used herein, a "drilling section" refers to any period between two connections in which the depth of the wellbore **106** has increased. When this occurs, the method **200** may include determining whether the depth of the wellbore **106** increases between two consecutive sets of measurements that occur between the two connections, as at **212**. If the depth of the wellbore **106** does increase between the two consecutive sets of measurements that occur between the two connections, it may be determined that the downhole tool **130** (e.g., the drill bit **138**) is drilling in the time interval between the two consecutive sets of measurements.

If the depth of the wellbore **106** does not increase between two the consecutive sets of measurements that occur between the two connections, the method **200** may include determining whether a time interval between the two consecutive sets of measurements is between two time intervals where drilling occurred, as at **214**. If the time interval between the two consecutive sets of measurements that occur between the two connections is between two time intervals where drilling occurred, then it may be determined that the downhole tool **130** (e.g., the drill bit **138**) is not drilling (i.e., the drilling activity is "non-drilling").

If the time interval between the two consecutive sets of measurements that occur between the two connections is not between two time intervals where drilling occurred, the method **200** may include determining whether the time interval between the two consecutive sets of measurements is between a time interval where one of the two connections occurred and a time interval where drilling occurred, as at **216**. If the time interval between the two consecutive sets of measurements is after a time interval where drilling occurred and before a time interval where a connection occurred, then the time interval between the two consecutive sets of measurements is determined to be a pre-connection interval. If the time interval between the two consecutive sets of measurements is after a time interval where one of the two connections occurred and before a time interval where drilling occurred, then the time interval between the two consecutive sets of measurements is determined to be a post-connection interval.

Thus, the method **200** may be used to determine drilling connection intervals by looking at (1) a depth of the wellbore **106**, (2) a depth of the drill bit **138**, (3) a position of the travelling block **105**, or a combination thereof, and without looking at hook load or WOB. In this case, noisy data that is often associated with the hook load measurement, or low threshold data recorded at the beginning of the wellbore (e.g., due to a low relative change in weight when the overall length of drill pipe is low) may be ignored.

FIG. **3** illustrates a graph **300** showing time intervals including drilling, pre-connection, connection, post-connection, and non-drilling activity, according to an embodiment. The time is shown on the X-axis and totals about 3 hours. A top quarter **310** of the graph **300** shows the depth of the wellbore **106** versus time. The next quarter **320** of the graph **300** shows the position of the travelling block **105** versus time. The next quarter **330** of the graph **300** shows time intervals where the downhole tool **130** (e.g., the drill bit **138**) is drilling, where a pre-connection occurs, where connection occurs, where post-connection occurs, and where non-drilling activity occurs. The bottom quarter **340** of the graph **300** shows the time intervals where the drill string **104** is engaged with, and supported by, the slips assembly **109** (i.e., in-slips) and where the drill string **104** is not engaged with, or supported by, the slips assembly **109** (i.e., out-of-slips). As may be seen, the travelling block **105** moves upward during a connection and downward during drilling. In addition, the drill string **104** is in-slips when a connection is occurring and out-of-slips when a connection is not occurring.

FIG. **4** illustrates a graph **400** showing time intervals where the downhole tool **130** is run into the wellbore **106** ("RIH") and pulled out of the wellbore **106** ("POOH"), according to an embodiment. The time is shown on the X-axis and totals about 40 minutes. A top quarter **410** of the graph **400** shows the depth of the wellbore **106** versus time. The next quarter **420** of the graph **400** shows the position of the travelling block **105** versus time. The next quarter **430** of the graph **400** shows time intervals where the drill string **104** and downhole tool **130** are run into the wellbore **106**, where a connection occurs, and where the drill string **104** and downhole tool **130** are pulled out of the wellbore **106**. The bottom quarter **440** of the graph **400** shows the time intervals where the drill string **104** is engaged with, and supported by, the slips assembly **109** (i.e., in-slips) and where the drill string **104** is not engaged with, or supported by, the slips assembly **109** (i.e., out-of-slips). As may be seen, the depth of the drill bit **138** increases when the downhole tool **130** is run into the wellbore **106**, remains constant during a connection, and decreases when the downhole tool **130** is pulled out of the wellbore **106**. The travelling block **105** moves downward when the downhole tool **130** is run into the wellbore **106**, remains constant during a connection, and moves upward when the downhole tool **130** is pulled out of the wellbore **106**. The drill string **104** is in-slips when a connection is occurring and out-of-slips when the drill string **104** and downhole tool **130** are run into the wellbore **106** and pulled out of the wellbore **106**.

FIG. **5** illustrates a graph **500** showing time intervals including when the drill string **104** and downhole tool **130** are run into the wellbore **106**, when pre-connections occur, when connections occur, when post-connections occur, when the downhole tool (e.g., the drill bit **138**) is drilling, when the downhole tool **130** (e.g., the drill bit **138**) is not drilling, and when the downhole tool **130** is pulled out of the wellbore **106**, according to an embodiment. The time is shown on the X-axis and totals about 3 days. Vertical columns represent hours, and horizontal rows represent minutes, with time proceeding upward and to the right (i.e., time begins in the lower left-hand corner and concludes in the upper right-hand corner).

As may be seen, the first 6-7 hours include alternating intervals of the drill string **104** and downhole tool **130** being run into the wellbore **106** and connections occurring to add segments to increase the length of the drill string **104**. Over approximately the next two days, drilling occurs, followed by a pre-connection, a connection, a post-connection, and more drilling. The last 4-5 hours include alternating intervals of the drill string **104** and downhole tool **130** being pulled out of the wellbore **106** and connections occurring.

In some embodiments, the methods of the present disclosure may be executed by a computing system. FIG. **6** illustrates an example of such a computing system **600**, in accordance with some embodiments. The computing system **600** may include a computer or computer system **601**A, which may be an individual computer system **601**A or an arrangement of distributed computer systems. The computer system **601**A includes one or more analysis modules **602** that are configured to perform various tasks according to some embodiments, such as one or more methods disclosed herein. To perform these various tasks, the analysis module **602** executes independently, or in coordination with, one or more processors **604**, which is (or are) connected to one or more storage media **606**. The processor(s) **604** is (or are) also connected to a network interface **607** to allow the computer system **601**A to communicate over a data network **609** with one or more additional computer systems and/or computing systems, such as **601**B, **601**C, and/or **601**D (note that computer systems **601**B, **601**C and/or **601**D may or may not share the same architecture as computer system **601**A, and may be located in different physical locations, e.g., computer systems **601**A and **601**B may be located in a processing facility, while in communication with one or more computer systems such as **601**C and/or **601**D that are located in one or more data centers, and/or located in varying countries on different continents).

A processor may include a microprocessor, microcontroller, processor module or subsystem, programmable integrated circuit, programmable gate array, or another control or computing device.

The storage media **606** may be implemented as one or more computer-readable or machine-readable storage media. Note that while in the example embodiment of FIG. **6** storage media **606** is depicted as within computer system **601**A, in some embodiments, storage media **606** may be distributed within and/or across multiple internal and/or external enclosures of computing system **601**A and/or additional computing systems. Storage media **606** may include one or more different forms of memory including semiconductor memory devices such as dynamic or static random access memories (DRAMs or SRAMs), erasable and programmable read-only memories (EPROMs), electrically erasable and programmable read-only memories (EEPROMs) and flash memories, magnetic disks such as fixed, floppy and removable disks, other magnetic media including tape, optical media such as compact disks (CDs) or digital video disks (DVDs), BLURAY® disks, or other types of optical storage, or other types of storage devices. Note that the instructions discussed above may be provided on one computer-readable or machine-readable storage medium, or alternatively, may be provided on multiple computer-readable or machine-readable storage media distributed in a large system having possibly plural nodes. Such computer-readable or machine-readable storage medium or media is (are) considered to be part of an article (or article of manufacture). An article or article of manufacture may refer to any manufactured single component or multiple components. The storage medium or media may be located either in the machine running the machine-readable instructions, or located at a remote site from which machine-readable instructions may be downloaded over a network for execution.

In some embodiments, the computing system **600** may include one or more drilling activity detection module(s) **608**. The drilling activity detection module(s) **608** may be used to perform at least a portion of the method **200**. More particularly, the drilling activity detection module(s) **608** may receive the sets of measurements and determine the drilling activity, the slips activity, or both.

It should be appreciated that computing system **600** is only one example of a computing system, and that computing system **600** may have more or fewer components than shown, may combine additional components not depicted in the example embodiment of FIG. **6**, and/or computing system **600** may have a different configuration or arrangement of the components depicted in FIG. **6**. The various components shown in FIG. **6** may be implemented in hardware, software, or a combination of both hardware and software, including one or more signal processing and/or application specific integrated circuits.

Further, the steps in the processing methods described herein may be implemented by running one or more functional modules in information processing apparatus such as general purpose processors or application specific chips, such as ASICs, FPGAs, PLDs, or other appropriate devices. These modules, combinations of these modules, and/or their combination with general hardware are all included within the scope of protection of the invention.

The foregoing description, for purpose of explanation, has been described with reference to specific embodiments. However, the illustrative discussions above are not intended to be exhaustive or to limit the disclosure to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. Moreover, the order in which the elements of the methods described herein are illustrate and described may be re-arranged, and/or two or more elements may occur simultaneously. The embodiments were chosen and described in order to explain at least some of the principals of the disclosure and their practical applications, to thereby enable others skilled in the art to utilize the disclosed methods and systems and various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

**1**. A method of determining a drilling activity, comprising:

receiving, by a computer, a set of measurements at a plurality of different times, wherein the set of measurements comprises a depth of a wellbore and a depth of a drill bit, both of which being provided to the computer by a sensor in the downhole tool, and a position of a travelling block;

identifying, by the computer, a connection by determining when the position of the travelling block changes and the depth of the drill bit does not change;

detecting drilling activity responsive to the computer determining that the depth of the wellbore increased between two connections, and determining that the depth of the wellbore increased between two sets of consecutive measurements occurring between the two connections;

detecting a post connection in a time interval between the two sets of consecutive measurements responsive to determining that the depth of the wellbore did not increase between the two sets of consecutive measurements occurring between the two connections, determining that the time interval between the two sets of consecutive measurements is not between two time intervals where drilling occurred, and determining that the time interval between the two sets of consecutive measurements is after a time interval where one of the two connections occurred and before a time interval where drilling occurred.

**2**. The method of claim **1**, further comprising determining a direction that the drill bit moves without using measurements of a hook load, a weight on the drill bit, or a combination thereof.

**3**. The method of claim **1**, further comprising determining that a drill string is engaged with, and supported by, a slips assembly when one of the connections occurs.

**4**. The method of claim **1**, further comprising:

responsive to determining that the depth of the wellbore did not increase between the two connections, performing:

detecting that a drill string and a downhole tool are run into the wellbore responsive to determining that the drill bit moves down between the two sets of consecutive measurements that occur between the two connections, and

detecting that the drill string and the downhole tool are being pulled out of the wellbore responsive to determining that the drill bit moves up between the two sets of consecutive measurements that occur between the two connections.

**5**. The method of claim **1**, wherein the determining that the depth of the wellbore did not increase between the two sets of consecutive measurements that occur between the two connections is performed without using measurements of a hook load, a weight on the drill bit, or a combination thereof.

**6**. The method of claim **1**, further comprising:

filling a gap in one of a measurement of the depth of the wellbore, a measurement of the depth of the drill bit, and a measurement of the position of the travelling block by carrying forward the one of the measurements from a previous time.

**7**. The method of claim **1**, further comprising determining that the drill bit is drilling without using measurements of a hook load, a weight on the drill bit, or a combination thereof.

**8**. The method of claim **1**, further comprising:

detecting a pre-connection in the time interval between the two sets of consecutive measurements responsive to determining that the depth of the wellbore increased between the two connections, determining that the depth of the wellbore did not increase between the two sets of consecutive measurements occurring between the two connections, determining that the time interval between the two sets of consecutive measurements is not between two time intervals where drilling occurred, and determining that the time interval between the two sets of consecutive measurements is after a time interval where drilling occurred and before a time interval where a connection occurred.

**9**. A non-transitory computer readable medium storing instructions thereon that, when executed by a processor, are configured to cause the processor to perform operations, the operations comprising:

receiving a set of measurements at a plurality of different times, wherein the set of measurements comprises a depth of a wellbore and a depth of a drill bit, both of which being provided by a sensor in a downhole tool, and a position of a travelling block;

identifying a connection by determining when the position of the travelling block changes but the depth of the drill bit does not change;

detecting drilling activity responsive to determining that the depth of the wellbore increased between two connections, and determining that the depth of the wellbore increased between two sets of consecutive measurements occurring between the two connections, and detecting a pre-connection in a time interval between the two sets of consecutive measurements responsive to determining that the depth of the wellbore did not increase between the two sets of consecutive measurements occurring between the two connections, determining that the time interval between the two sets of consecutive measurements is not between two time intervals where drilling occurred, and determining that the time interval between the two sets of consecutive measurements is after a time interval where drilling occurred and before a time interval where a connection occurred.

**10**. The non-transitory computer readable medium of claim **9**, wherein the determining that the depth of the wellbore did not increase between the two sets of consecutive measurements that occur between the two connections is performed without using measurements of a hook load, a weight on the drill bit, or a combination thereof.

**11**. The non-transitory computer-readable medium of claim **9**, further comprising:

responsive to determining that the depth of the wellbore did not increase between the two connections, performing:

detecting that a drill string and a downhole tool are run into the wellbore responsive to determining that the drill bit moves down between the two sets of consecutive measurements that occur between the two connections, and

detecting that the drill string and the downhole tool are being pulled out of the wellbore responsive to determining that the drill bit moves up between the two sets of consecutive measurements that occur between the two connections.

**12**. The non-transitory computer-readable medium of claim **9**, wherein the operations further comprising:

filling a gap in one of a measurement of the depth of the wellbore, a measurement of the depth of the drill bit, and a measurement of the position of the travelling block by carrying forward the one of the measurements from a previous time.

**13**. The non-transitory computer-readable medium of claim **9**, further comprising determining a direction that the drill bit moves without using measurements of a hook load, a weight on the drill bit, or a combination thereof.

**14**. A computing system, comprising:

a processor; and

a memory system comprising one or more non-transitory computer readable media storing instructions thereon that, when executed by the processor, are configured to cause the computing system to perform operations, the operations comprising:

receiving a set of measurements at a plurality of different times, wherein the set of measurements comprises a depth of a wellbore and a depth of a drill bit, both of which being provided by a sensor in a downhole tool, and a position of a travelling block being provided by an encoder;

identifying a connection by determining when the position of the travelling block changes but the depth of the drill bit does not change;

detecting drilling activity responsive to determining that the depth of the wellbore increased between two connections, and determining that the depth of the wellbore increased between two sets of consecutive measurements occurring between the two connections;

detecting a post connection in a time interval between the two sets of consecutive measurements responsive to determining that the depth of the wellbore did not increase between the two sets of consecutive measurements occurring between the two connections, determining that the time interval between the two sets of consecutive measurements is not between two time intervals where drilling occurred, and determining that the time interval between the two sets of consecutive measurements is after a time interval where one of the two connections occurred and before a time interval where drilling occurred; and

detecting a pre-connection in the time interval between the two sets of consecutive measurements responsive to determining that the depth of the wellbore did not increase between the two sets of consecutive measurements occurring between the two connections, determining that the time interval between the two sets of consecutive measurements is not between two time intervals where drilling occurred, and determining that the time interval between the two sets of consecutive measurements is after a time interval where drilling occurred and before a time interval where a connection occurred.

**15**. The computing system of claim **14**, wherein the operations further comprise filling a gap in one of a measurement of the depth of the wellbore, a measurement of the depth of the drill bit, and a measurement of the position of the travelling block by carrying forward the one of the measurements from a previous time.

**16**. The computing system of claim **14**, wherein the operations further comprise determining that the drill bit is drilling without using measurements of a hook load, a weight on the drill bit, or a combination thereof.

**17**. The computing system of claim **14**, wherein the detecting the post connection occurred without using measurements of a hook load, a weight on the drill bit, or a combination thereof.

**18**. The computing system of claim **14**, wherein the operations further comprise:

responsive to determining that the depth of the wellbore did not increase between the two connections, performing:

detecting that a drill string and the downhole tool are run into the wellbore responsive to determining that the drill bit moves down between the two sets of consecutive measurements that occur between the two connections, and

detecting that the drill string and the downhole tool are being pulled out of the wellbore responsive to determining that the drill bit moves up between the two sets of consecutive measurements that occur between the two connections.

**19**. The computing system of claim **14**, further comprising determining a direction that the drill bit moves without using measurements of a hook load, a weight on bit, or a combination thereof.

**20**. The computing system of claim **14**, further comprising:

detecting non-drilling activity responsive to determining that the depth of the wellbore increased between the two connections, determining that the depth of the wellbore did not increase between the two sets of consecutive measurements occurring between the two connections, and determining that a time interval between the two sets of consecutive measurements is between two time intervals where drilling occurred.

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